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ABSTRACT

Two studies compared motor skills of women in terms of the influence of age and activity level. In the first study, simple and choice reaction time, balance, flexibility, and grip strength of older active women were compared with that of older inactive women, and active and inactive younger women. Except for grip strength, scores of older active women on all measures were significantly better for older inactive women, and much more like those of the younger women. In the second study, scores of avid women golfers were compared with those of the older active and inactive women in the first study. On all variables, the scores of golfers were significantly better than those of older inactive women, but not significantly different from the older active women. These findings were consistent with previous research on men, indicating that motor performance tends to be more highly related to lifelong physical activity level than to age. (Author/CB)

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Motor Performance of Women as a Function of Age and Physical Activity Level[1]

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In Study 1, simple and choice reaction time, balance, sit and reach flexibility, shoulder flexibility, and grip strength of older active women were compared with older inactive women, and active and inactive younger women. Except for grip strength, scores of older active women on all measures were significantly better than for older inactive women, and much more like those of the younger women. In Study 2, scores of avid women golfers were compared with the older active and inactive women from Study 1. On all variables, the scores of golfers were significantly better than those of the older inactive women, but not significantly different from the older active women. Findings were consistent with previous research on men, indicating that motor performance tends to be more highly related to lifelong physical activity level than to age.

Key Words: Exercise, Humans, Females, Cognitive processing, Life style

A considerable amount of evidence supports the familiar "aging curve" for many psychomotor and physical functions, including reaction time, balance, flexibility, and grip strength (Adrian, 1981; de Vries, 1979; Eckert, 1975; Eckert & Espenschade, 1980; Hasselkus & Shambes, 1975; Hellenbrandt & Braun, 1939; Hodgkins, 1963; Pierson & Montoye, 1958; Shock, 1962). Generally, performance improves with age through the early and mid-20s, levels off for a short time, and then shows a gradual or a rather marked decline.

Recent research, however, suggests that people who maintain a physically active lifestyle do not experience these typical declines. Older men, for example, who were physically active in racket sports and running were found to have reaction times and movement times that were more comparable with those of college-aged men, than with those of their inactive older peers (Clarkson & Kroll, 1978, Spirduso, 1975; Spirduso & Clifford, 1978). Similarly, in an earlier study, Pierson and Montoye (1958) found that movement times were slower in older men, except those who maintained an active lifestyle. Movement time was actually faster in older active men than in younger nonactive men.

As suggested by Spirduso (1980) in a recent review of literature, little is known about the motor performance of older women. This is most likely due to past difficulties in locating a population of older women who had maintained a physically active lifestyle. Scarborough (cited in Spirduso, 1980) indicated that there is only a "tendency" for active older women to have faster choice reaction times than inactive older women. Unlike the research on men, in which active older men performed much better than inactive older

men and as well as or better than younger men, active older women in the Scarborough study performed more like inactive older women than younger ($\underline{M}$ = 20 years) women. Unfortunately, the mean age of the older women in this study was only 45. Thus, research is needed to determine whether the effects of a physically active lifestyle during aging is as significant for women as it appears to be for men on various parameters of motor performance.

Study 1

The purpose of this investigation was to study the relationship between physical activity level and motor performance of women by using the same young/old, active/inactive cross-sectional design (with equivalent age groups) as used previously with men (Clarkson & Kroll, 1978; Spirduso, 1975; Spirduso & Clifford, 1978). The variables tested were simple and choice reaction times (comparisons are made with previous findings on men), and balance, flexibility, and grip strength. The latter three variables were included because they are considered important to older people in performing normal activities associated with daily living.

As with most other physical performance variables, balance (Eckert & Espenschade, 1980), flexibility (Adrian, 1981), and grip strength (Shock, 1962) are normally found to decrease significantly with age. It is not clear, however, whether these declines are primarily a function of declining age or are more highly related to some other variable such as disuse or low levels of physical activity. For instance, Adrian (1981), in a summary of the literature on flexibility, pointed out that, although decreases in flexibility

typically occur with advancing age, there is no evidence that biological changes cause those decreases.

Presently, little is known about the performance patterns of women who have been physically active throughout their lives compared with those who have not. Based on the limited amount of available literature, the prediction was made that performance patterns of women would be similar to those reported for men, with active older women scoring significantly better than inactive older women. More specifically, it was hypothesized that there would be significant main effects for age and activity level. In addition, it was proposed that the Age x Activity level interaction would be significant, due to wider performance differences between the older active and inactive women compared with the younger groups.

METHOD

Participants

The participants were 60 female volunteers, classified into one of four groups of 15 participants each: (a) young active (M = 22.2 years of age); (b) young inactive (M = 21.1 years); (c) old active (M = 68.7 years); and (d) old inactive (M = 68.9 years).

Inactive women had never participated in vigorous physical activity of any type on a regular basis, either for the purpose of exercise or for occupational or other lifestyle demands. The young active group comprised of college students who had been involved in vigorous physical activity on a regular basis (at least three times a week for at least 30 min a day for the

past 3 years or more); the older active women had participated in vigorous activity for the past 10 years or more on a regular basis (at least 3 times a week for at least 30 min a day). Vigorous physical activity was defined as activity that was strenuous enough to cause rapid heart rate, heavy breathing, and considerable perspiration. Aerobic exercise, running, and competitive racket sports were the most common activities of the active group. Participants selected for inclusion in the study were judged (according to a self-report health status questionnaire) to be free of any physical or health impairments that might have hindered their performance on the dependent variables and were equated as much as possible on potentially relevant variables such as smoking, socioeconomic status, and nonphysical activity levels.

Performance

Performance was assessed on the following tasks in the given order for all participants: simple reaction time, choice reaction time, balance, sit and reach flexibility, shoulder flexibility, and grip strength.

Reaction time--Measurements were obtained from a Lafayette Company Choice Reaction Time apparatus (Model #63035). Reaction time was defined as the latency from the onset of the visual stimulus to the depression of the microswitch. To obtain simple reaction time only one of the lights was used. For choice reaction time the women responded to one of two lights. The decision as to which light was to be activated was made in advance by random assignment. During simple reaction time testing the woman sat with the index finger of her dominant hand resting lightly on the microswitch. During choice

reaction time testing the index fingers of both hands were used. For both tests, foreperiod delays between 1.5 to 4.0 s were randomly rotated after a verbal "ready." Following two practice trials, 10 test trials were administered with 20-s intervals between trials. In order to eliminate the early effects of learning, only the last 8 of the 10 trials were used in determining the mean scores for the analysis. A reliability of .87 has been established for this procedure (Haywood & Temple, 1976).

Balance--Static balance was measured by having each woman balance, with eyes open and arms out, on her preferred foot with the other foot off the floor. The score was the number of seconds between the time the nonpreferred foot was raised and balance was lost (when the woman began to hop around or when the raised foot was lowered to the floor). Each woman performed three trials. Only the highest score was recorded.

Flexibility--To measure sit and reach flexibility, a specially constructed 15 x 15 x 15 inch box was used, similar to the one described in the AAHPERD Health Related Physical Fitness Test Manual (1980), upon which a meter stick was attached extending 45 cm in front of and 45 cm beyond the front edge of the box. The participants were instructed to sit with their feet positioned flat against the flexibility apparatus with knees fully extended and feet together with the inner borders touching. While the experimenter pressed down on the knees to keep them extended, each participant was instructed to stretch forward slowly with hands and arms outstretched as far as possible toward or past the toes for a maximum of 1 s. Three trials were given with the best score recorded to the nearest centimeter.

Shoulder flexibility was assessed by having the woman place her preferred hand over that same shoulder down the back and, with the nonpreferred hand behind the back, reaching as far as possible in an attempt to touch or overlap the middle fingers. While the participant held this position, a measurement either short of touching the middle fingers together (-) or overlapping them (+) was taken. Three trials were given, with the best score recorded to the nearest centimeter.

Grip strength--Grip strength was measured by a Lafayette Hand Dynamometer calibrated to 100 kg of force. Each woman held the dynamometer in the preferred hand with the arm down at her side and squeezed to maximum force. Three trials were given with 30 s rest between trials. The best score, to the nearest kilogram, was used in the analysis.

Analysis

The data were analyzed using a 2 x 2 factorial variance analysis for each of the six dependent variables (i.e., simple reaction time, choice reaction time, balance, grip strength, sit and reach flexibility, and shoulder flexibility). The two independent variables were age (young and old) and physical activity level (active and inactive). Significant interactions were analyzed by a simple effects analysis of variance.

Insert Tables 1 and 2 about here

RESULTS

The means and standard deviations of the performance variables are shown in Table 1. As predicted, the age and activity level main effect F ratios

(Table 2) were significant for all dependent measures. In each case, overall mean scores for the young women were better than for the older women, and for active compared with inactive women. The Age x Activity level interaction was significant on the choice reaction time, balance, and shoulder flexibility tasks. Simple effects post hoc comparisons indicated that all interactions appeared to be due to larger differences between the active and inactive older women than between the active and inactive younger women.

On all variables, except for grip strength, performances of the women in this study were similar to those of men in previous studies (Clarkson & Kroll, 1978; Spirduso, 1975; Spirduso & Clifford, 1978) in that scores of active older participants were more similar to college-age participants than to their own inactive counterparts. Specifically, on the simple reaction time task significant differences were found between the old active and inactive participants, (F 1, 28) = 10.35, $p < .01$, but not between the young active and inactive groups, nor between the old and young active groups.

On the choice reaction time task, the old active and inactive women differed significantly, $F(1, 28) = 16.51$, $p < .001$, as did the young active and inactive women, $F(1, 28) = 11.00$, $p < .01$, but not quite as dramatically. Again, there was no significant difference between the old and young active women. Performance patterns on the balance and shoulder flexibility tasks were similar to those of the simple reaction task. There were large differences between the old active and inactive women on balance, $F(1, 28) = 15.45$, $p < .001$, and on flexibility, $F(1, 28) = 18.04$, $p < .001$, but there were no significant differences among the old active, young active, and young inactive

groups on these two tasks. On the sit and reach task, there were significant differences between old active and inactive women, $F(1, 28) = 11.88$, $p < .01$, between the young active and inactive women, $F(1, 28) = 9.29$, $p < .01$, and between the old and young active groups, $F(1, 28) = 5.99$, $p < .05$. Only on the grip strength task were differences nonsignificant between the old active and inactive women, but significant for the young and old active groups, $F(1, 28) = 13.84$, $p < .01$.

STUDY 2

In the previous study, performance patterns of only the extreme activity levels (vigorously active women vs. inactive women) were studied. Little is known about motor performance profiles of people with more moderately active lifestyles. Because golf is one of the more common sport activities for adult women, it was decided to test a comparable age group of older women golfers, following the same procedures as in Study 1. Scores of the golfers were compared with those of the initial participant pool of active and inactive older women. It was predicted that golfers would score significantly better than the inactive women, but significantly lower than the highly active group.

METHOD

Participants

The participants were 15 female volunteer golfers ($M = 69.5$) who, on the average, walked (pulled a cart) about 50% of the time and rode a cart about 50% of the time. To qualify for the study, the women had to have played golf as their only regular sport and their primary source of physical activity for at least the past 10 years on an average of at least two to three times (18

holes) per week. Most of the women played more often than this. Many reported playing "almost every day," with the average approximately 3.5 times a week. None of the golfers participated in any type of vigorous or aerobic-type activity, as was characteristic of "vigorously active" women in Study 1.

Procedures

The instrumentation and test administration procedures were identical to those used in Study 1.

RESULTS

One-way analyses of variance were used to compare the scores of golfers with the scores of older vigorously active and older inactive subjects from Study 1. On all dependent variables F ratios (df = 2, 42) were significant beyond the .05 level: simple reaction time, $F = 5.58$; choice reaction time, $F = 14.16$; balance, $F = 7.45$; sit and reach flexibility, $F = 9.44$; shoulder flexibility, $F = 11.78$; grip strength, $F = 4.84$. Newman-Keuls post hoc comparisons were made to determine significant group mean differences. As predicted, the golfers scored significantly better than the inactive women on all tasks, but did not, as predicted, score significantly lower than the vigorously active older women. Group means and standard deviations are presented in Table 2.

There were highly significant differences (beyond the .01 level) between the golfers and the older inactive women on choice reaction time ($q = 6.28$), sit and reach flexibility ($q = 4.90$), shoulder flexibility ($q = 5.3$), and grip strength ($q = 4.37$). Significant differences beyond the .05 level were found

for these same groups on simple reaction time (q = 2.93) and balance (q = 3.73). There were no significant differences between the golfers' scores and the scores of the more vigorously active women.

DISCUSSION

The results of Study 1 suggest that for women, as reported for men, quality of motor performance during aging may be more a function of degree of physical activity level than of age. Those who had been physically active throughout life did not exhibit the classic aging decreases in performance. As shown in Table 1, scores of active older women are generally more similar to younger women than to their older inactive peers. In all cases, except for grip strength, there were significant differences between the older inactive women and the other three groups. Smaller or no differences were found between the older active, young active, and young inactive groups. On the grip strength task, differences between the older active and older inactive women did not reach significance. The discrepant results on the grip strength task may be due to the fact that two of the women in the older active group had had masectomy operations earlier in life but failed to report them when original screening was done for participants.

The results of Study 2 indicate that women golfers, at least very avid ones as described in this study, have motor performance scores similar to those of the more vigorously active older women. It is surprising that golf, a fairly nondemanding activity compared with aerobics, running, and/or racket sport activities of the older active group, would produce results similar to those of more vigorous sports. Perhaps it is possible that, for the types of

psychomotor/physical performances measured in this study, the larger amount of time (duration of activity) associated with golf participation in some way equalizes the effects of the shorter, but higher intensity characteristics of more vigorous activities.

Results of this investigation and other similar studies (Clarkson & Kroll, 1978; Spirduso, 1975; Spirduso & Clifford 1978) suggest that a chronically active lifestyle plays an important part in preventing age-related declines in motor performance. Psychomotor declines during aging, especially reaction time, is of concern not only because of the effect on physical functioning, but also as a reflection of cognitive performance, because reaction time is considered an important indicator of overall cerebral status (Birren et al., 1980).

Although causation can not be established from this study, some recent experimental findings from animal research suggest that a causal interpretation of the positive relationship between exercise and aging may be warranted. There is evidence, for example, that exercise may positively affect both cognitive and psychomotor performance because of its influence on the production and/or function of certain neurotransmitters within the brain, for example, dopamine, norepinephrine, and serotonin (Gilliam et al., 1984; Spirduso & Farrar, 1981; Spirduso et al., 1984). Others suggest that exercise may have a positive effect on human cognitive processing time (reaction time) because of its influence upon oxygen level in the brain (Birren et al., 1980; Shephard & Kavanaugh, 1978).

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Table 1. Means and Standard Deviations (in Parentheses) of Motor Performance Variables as a Function of Age and Activity Level.

	Young		Old		
Variable	Active	Inactive	Active	Inactive	Golfers
Simple reaction time (msec)	242.80 (15.97)	257.40 (21.18)	248.60 (24.59)	264.20 (31.47)	290.33 (43.80)
Choice reaction time (msec)	275.47 (21.36)	313.07 (38.35)	295.13 (33.33)	301.20 (25.44)	385.60 (79.53)
Balance(s)	60.00 (0.0)	60.00 (0.0)	47.73 (19.15)	39.47 (21.01)	20.13 (19.31)
Sit and reach flexibility (cm)	12.47 (9.29)	3.40 (6.13)	4.33 (8.56)	2.60 (4.50)	-8.27 (10.89)
Shoulder flexibility (cm)	8.60 (3.94)	7.87 (4.27)	4.87 (4.58)	2.60 (5.04)	-6.00 (8.79)
Grip strength (kg)	31.49 (4.78)	29.13 (4.55)	22.67 (3.17)	24.66 (3.48)	20.07 (5.15)

Table 2. F Ratios from Analysis of Variance for Age and Activity Level.

Task	Source		
	Age	Activity	Age X Activity
Simple reaction time	6.87**	14.53***	3.37
Choice reaction time	13.62***	26.28***	4.48*
Grip strength	57.66***	4.45*	.01
Balance	55.11***	15.45***	15.45***
Trunk flexibility	17.66***	21.15***	.56
Shoulder flexibility	34.36***	14.93***	11.39***

NOTE: The degrees of freedom for each F ratio are 1 and 56.

* $p < .05$. ** $p < .01$. *** p , .001.